Smartphone-based Human Fall Detection System

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Abstract

This research shows the use of a smart-phone device in saving a person’s life. Nowadays, from PCs to mobile phones, advancement society in their activities, being these eventually or co-operatively. Because of these ideal circumstances, new research has make to make structures and applications to help with people’s prosperity, for our circumstance recognizing fall incidents with the usage of mobile phones. This paper acquaints a route with manage recognize falls using unmistakable proposed computations with the target of peopling with their prosperity and security. The system is made out of three one of kind fragments: data gathering, range decision, and fall ID. It utilizes the wireless’ intrinsic sensors (accelerometer, whirligig) to recognize the region of the mobile phone in the customer's body (mid-segment, pocket, holster, ET cetera.) and once a zone is perceived, the fall distinguishing proof portion happens. A general depiction on fall area systems is given, including the differing sorts of sensors used nowadays. The proposed course of action is presented and depicted in wonderful unobtrusive component. A total accuracy of 81.3% was found out from the fall distinguishing proof proposed computation. The primary three regions to recognize a fall were: informing with 95.8% fall area accuracy, pants’ side pocket with an 87.5% precision, and shirt mid-segment pocket with an 83.3% precision. In like manner an extra study was done using only the holster territory making an awesome 100% region decision accuracy.

Key Words: Range decision, fall ID, intrinsic sensors, accelerometer & whirligig sensors.
1. Introduction

Nowadays the senior citizens have a lot of risk of falling anytime and anywhere. Especially for those who are living alone at the old age, they can fall anytime and no one will be there to help him too. People suffering from various diseases, stress, tension, agitation are the people who tend to do accidents more. According to a report given by the government, there are about 1.46 lakh people who have been dead due to road accidents in the year 2015, which is an increase of 5% than the previous year. Accidents has been risen up by 2.5 per cent during 2015 to 5.01 lakh that is a total of 374 accidents per day, in which 400 people’s lives have been gone. In majority (54.1 per cent) of those who were dear in 2015 were in the age group of 15-34. Several States, including Tamil Nadu, Karnataka, Kerala and Uttar Pradesh, Maharashtra, Madhya Pradesh have the records for highest amount of accidents. Amongst these metropolitan cities, Mumbai has the highest number of accidents (23,468); Delhi has the highest deaths among the accidents (1,622). And people who are admitted in the hospital with serious crisis are around 30%. The fear of falling is not only amongst the elderly people but also with the young population who meet with accidents very frequently. The number of Accidents have been increased over the years periodically. Let’s have a look at it in detail:

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of accidents</th>
<th>Number of persons</th>
<th>Accident severity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>Fatal</td>
<td>Killed</td>
</tr>
<tr>
<td>2002</td>
<td>40,749</td>
<td>73,650</td>
<td>(19.1)</td>
</tr>
<tr>
<td>2003</td>
<td>40,726</td>
<td>73,590</td>
<td>(18.1)</td>
</tr>
<tr>
<td>2004</td>
<td>42,991</td>
<td>70,357</td>
<td>(18.5)</td>
</tr>
<tr>
<td>2005</td>
<td>43,255</td>
<td>83,491</td>
<td>(19.9)</td>
</tr>
<tr>
<td>2006</td>
<td>46,020</td>
<td>93,917</td>
<td>(20.4)</td>
</tr>
<tr>
<td>2007</td>
<td>47,026</td>
<td>1,01,161</td>
<td>(21.1)</td>
</tr>
<tr>
<td>2008</td>
<td>48,470</td>
<td>1,06,591</td>
<td>(22.0)</td>
</tr>
<tr>
<td>2009</td>
<td>48,036</td>
<td>1,10,993</td>
<td>(22.8)</td>
</tr>
<tr>
<td>2010</td>
<td>49,628</td>
<td>1,15,550</td>
<td>(23.9)</td>
</tr>
<tr>
<td>2011</td>
<td>49,768</td>
<td>1,21,619</td>
<td>(24.4)</td>
</tr>
</tbody>
</table>

Even young people with various diseases which can cause unconsciousness etc are in real danger. Immediate medical help are needed in such cases, but often when these people fall, they won’t even be able to move and since no one is there to help them, they pass away. There were many solutions made for such a crisis where a new emergency button system was introduced where when someone needs help, they need to press the button for immediate help. Now the major drawback of this method is that if the person gets unconscious at that very moment, then he won’t be able to reach for the button. Everything is automatic in this world and therefore it is vital to introduce a detection technique without and help of humans. World Health Organization (WHO) definition of a fall: “Body coming to rest in the ground level or ground state accidentally or without any intention”. These falls always occur in some motion or pose, by observing these things some may provide us with information about the fall. There are n numbers of sensors that can be used to detect human fall activity. According to the Current scenario, we can detect the fall in three methods.1) video-based
methods 2) acoustics-based methods and 3) wearable sensor-based methods. In video based sensors there are many issues like the privacy concern and in the acoustic one is not that efficient. Hence we use wearable sensors in automatic fall detection. In video base and acoustic sensor, we need ore installation and lots of wiring. On the other hand, only when a person is attached with the wearable sensor, it will work. Number of accidents in the year 2015.

Even if we use it outdoor, the wearable sensor detects the fall. In the present century, Smartphone is a must in everyone’s home. And due to this high usage even with the normal man, there will be no such person without a Smartphone. The prices have also dropped so less that everyone started buying more than one phone. In order to establish communication between the user and the Smartphone’s, there is an accelerometer already available in the android devices. The acceleration signals could be retrieved from the integrated accelerometers. This mechanism could be used to advance an application that specializes in fall activity. In this paper, what we have done is that we have collaborated a fall detection app that runs in Android 5.0 and used in any Smartphone’s. We use discrete wavelet transform for receiving the input and we use different frequency to detect he fall action and the frequency domain to Differentiate ever action from each other. We examine the performance of every fall and to keep it different from the normal movements, compare the falls by differentiating it, such as hopping or sleeping in bed. The best part about the Smartphone based fall detection is that we are using integrated GPS that helps in sending immediate information about the fall to the interested people that were been added in the application through sms, twitter, email etc. In the previous years all the previous search engines failed to update the user with the location because of two major reasons. One of the reasons is that, previously there not so many people using the Smartphone. Especially Smartphone’s with GPS. Secondly, the web information is not very relevant. Since nowadays everyone have started using the Smartphone, it has become easier to find the location of the people using GPS. All the search engines have been updated and connected to the Smartphone devices. We can also block the location by changing the privacy settings depending on the search engines. The application only extracts information with the permission of the user. By using this method, the results have turned out to be very good and efficient. Due to the location plotting method, things have become more liable and trust worthy. The navigation attachment to the application is one of the biggest successes that have been gained in the recent years. In order to protect all the elderly people
and the people who have their lives under danger due to accidents, there were many proposed systems and types and model. But this Smartphone based fall detection method could be really useful and very efficient. There were many trails and demonstrations taken during developing this particular application to check the efficiency of the application.

2. Related Work

There are many people who have been working on the fall detection. The use of sensors was the biggest challenge as they were various wearable Sensors that could be used. AhmetTuran [1] has done a similar one, were they attached wearable sensors in 6 different unit positions in the human body to detect the fall. Every unit consists of 1. Accelerometer, 2.Gyroscope and 3. Magnetometer/compass i.e. the tri-axial devices. There were plenty voluntary experiments performed in a normal set of actions and movements which contains 20 voluntary falls and 16 regular day to day activity, that results in a large database array with plenty of trails, in every sensor the main focus is on the raw material that is around the end point and then the extraction process takes place followed by the reduction.

Another one is detecting to visual sensors given by Jean in [2], where the computer uses is camera sensation to detect the fall that happens right in front of it. His methodology was based on human shapes. Every fall has a shape. So the video sequence would record the shape and detect the fall. To detect the shape made, they use and shape matching technique. The shapes are then figured by using the deformation methods. Gaussian mixture model is used to detect the final fall.

His paper has been sent to various demonstrations and experiments which has proven its efficiency and has no error in it (up to zero% with lots of camera arrangement) in comparison with the other pictorial processing methods.

LingmeiRen [4] proposed the conception-based fall detection that has been used in standard fall detection systems. The flexibility of threshold is not that much with the people. By removing the adaptive threshold, they have introduced a new threshold model i.e. novel threshold extraction model. This model detects the fall more efficiently by only considering the data from activity of daily living (ADL). This has taken enormous growth in the threshold based detection performance. To check the quality of this threshold extraction model, various comparisons were made with an animal and compared with advanced magnitude detection (AMD) and fixed and tracking fall detection (FTFD). After various experimentations, the results showed that the animal (chameleon) has an accuracy of 95.82% When the fall was detected, which when compared with the others were 1.66% higher than FTFD and 2.66% higher than AMD. The best part is that the sensitivity of the algorithms was very high in this case. To know more about this, it is given in details in [4]. People then felt the need to save the elderly without risk.
In [6] Hegdea created on especially to detect fall of patients and aged people. They may need help anytime. His idea was to basically help the elderly and connect them with emergency medical help by setting an alarm during the time of fall. In order to save them, it is necessary to keep them under surveillance 24/7. In his paper he has reviewed history of fall detection system, different algorithms used to detect fall, different sensors used such as wearable sensor, combined sensors, ambient sensors and the application of each sensors is studied in detail. Thus the requirement of a fall detector is increasing day by day.

In [7] Alex Mihailidis discovered nowadays everyone has started living an independent life and anything can happen to anyone anytime irrespective of the place or surroundings. This world is a very risky world and it is important to save the people who are at risk. Due to which this emerged- ‘ambient-assisted living’ (AAL). It is a tool especially for older adults which was based on their methodology. The application that we have propose makes sure to solve all the issues and provides the elders as well as the youngster with the chance of saving their lives in times of emergency. We have also worked against the false alarm beep but putting an timer. So in case of a not a serious fall, the user and turn off the alarm in 20 seconds.

3. Fall Detection Algorithm

Discrete wavelet transform (DWT) basically yields a multi-scale representation of a discrete signal, formed by iteratively applying the analysis filters to the original signal. The transformation begins with a selection of a mother wavelet, $\Psi$, from which the Analysis filters, $h$ and $g$, are formed. Then the wavelet coefficients of a discrete signal $x$ at the first scale are calculated as:

$$\alpha_s[n] = \sum_{k=-\infty}^{\infty} x[k]h[n-k] = (x * h)[n]$$

$$d_s[n] = \sum_{k=-\infty}^{\infty} x[k]g[n-k] = (x * g)[n]$$

Where, $a$ represents the approximation coefficients and $d$ represents the detail coefficients. Because of the analysis nature, filters $h$ and $g$, approximation and detail coefficients contain half of the frequency components of the original signal and therefore can be sub sampled by two. After the sub sampling, approximation coefficients can be used to measure the efficiency in a different ruler effectively forming a filter bank:

$$\tilde{a}_{ss}[n] = \sum_{k=-\infty}^{\infty} \tilde{a}_s[k]h[n-k] = (\tilde{a}_s * h)[n]$$

$$\tilde{d}_{ss}[n] = \sum_{k=-\infty}^{\infty} \tilde{a}_s[k]g[n-k] = (\tilde{a}_s * g)[n]$$

Where $a$ represents the sub sampled approximation coefficients of scale $s$. The process of the wavelet transformation decomposes a signal by concentrating the
signal energy in a tiny numerical way to check the efficiency [3]. It is this property of reducing a signal to a comparatively small number of components that makes wavelet-based techniques potentially powerful for signal processing algorithms. For further references look at [5].

\[
F(n) = \begin{cases} 
1 & \text{if } \overline{a_i}(\frac{[n]}{2}) > t \\
0 & \text{if } \overline{a_i}(\frac{[n]}{2}) < t
\end{cases}
\]

The extraction method that is used over here is the DWT method. DWT is applied to the discrete Acceleration signal provided by the integrated accelerometer, \(X\), in order to extract the detail coefficients of \(X\) at the first scale. When the fall activity crosses the threshold frequency then the fall is detected at that current scenario. Formally: Where \(F(n)\), is the fall decision for the \(X[n]\), and is the sub sampled detail coefficients at the first scale, and is the floor function.

4. Implementation

This Smartphone application was made for people where the accident of fall happened suddenly and without any knowledge like coma patients, the elderly as well all the other diseases where there is loss of consciousness. It uses the incredible sensing capability of the android device and the wavelength signal to detect the fall immediately. The working process is given in the picture below (fig.1). this application when detected a fall, it’s basically makes others aware of the fall through social media like twitter, emails and sms alerts too so that they can come and rescue the user from the crisis. Best part is that is also sends the location of the user. These emergency messages contain the location information shown on the map application. In case of not a serious fall, then we can also turn the alarm off as there is a timer of 20 seconds set to avoid all the fake or not risky falls.

![Figure 1: Internet location info fall detection GPS E-mail twitter update SMS MMS](image.png)

The Overview of Fall Detection Application

We have introduced a Smartphone based fall detection system in Android 5.0 and above. As we all know, one amongst the few open source operating system,
android is one and the most popular one in them. It has also SQL and Lite database management system. The core of the application is composed of five parts:

**Login & Registration**

In this module we design to develop login and signup screen. Android used xml to develop classical screens in our application. The modules describe signup page contains email id or user name, password and conform password those kind of details should be stored in database. Login screen contains email id or username and password when the user to login the app it should be retrieve the data to the database and combine based on user input if its match user name and password to allow in the app otherwise alert and show a message to the user.

**Database Creation**

User email id or user name and password have been stored after registration. Android used SQLite Database for storing and fetching user application details. The datas are stored in the form of tables so that we can retrieve it during the time of login.

**Start Session**

This is where the application gets started after it receives the basic information from the user and saves it in the database. The application now starts running its session and starts checking the fall activity. Without starting the application, the fall won’t be detected. Start is very important.

**Check Motion for Mobile**

Now once the process has been started, now its checks of an in appropriate change in the tri-axial axis i.e. the abnormal falling axis and when it does it immediately gets prompted and sends and immediately send an message. It keeps a track of every body movement to check in with the fall axis so that the alarm can ring during the fall. An immediate message will be sent across when fallen.

![Figure 2: Login & registration](image-url)
Mobile Vibrating

The mobile vibrate when a fall occurs. We can switch off the alert message if it is not a serious fall. Mobile vibrating is a sensor that is available in the entire cellular device which can be used for various other purposes like prompting. The vibration is attached with an alarm sound that enables the user to turn it off in case of false alarm.

The vital thing about this application is its simplicity and the easy, friendly and admix design. The major buttons in applications are as follows: 1. Login button: Here we have to login into our account to accept the access of the google maps and to have a separate database for every user. 2. Star button: Begins the Smartphone based fall detection application to detect falls. 3. End button: Ends the service provided by the application to save the battery or for various other reasons. On the top of the android device, we will be able to see whether the app is in the active state or not. 4. Alarm Button: In case of sending a message to the caregivers voluntarily without a fall or anything asking for help, this button is used. If in case you’re lost somewhere and you want someone to reach you and save your life, on clicking on this button, the message will be sent along with the location details. 5. Settings button: This is used to change the account information password and other privacy stuffs. It also is used the add/remove caregivers information and details. There are various features and settings available that we and do and change as per the users wish. The following are the few:
1. It is the users wish to select the caregivers to whom the SMS will be sent in case of a fall activity. The sms sent will also include the location coordinates.

2. It is the users wish to select the caregivers to whom an E-mail will be sent in case of a fall or alarm. The mail will be attached to a Google map link which will contain the exact location of the fall occurrence.

3. Even twitter account could be added. More than one account also could be added. So in case of the fall, there will be an immediate tweet that will be sent across to the users caregivers along with the location detail.

During the time of a fall, there will be an alarm that will ring in our Smartphone that is timed for about 20secs. So in case of a fake fall or a non risky fall, we always have the option of turning the alarm off so that our caregivers need not be tensed or worried. The 20 second time limit has been kept with a lot of thinking which enables the slowest of the slowest person to also come and off the alarm and in case of emergency, 20secs wont delay a lot in saving. So if the user does not experience a real fall, the person can turn the alarm down and continue his work. And if an real fall or accident has occurred, the within 20seconds the caregivers will receive and sms mail etc and the user may expect immediate help in times of serious Trouble. This also helps us the Separate all the misunderstanding of the falls that occurs between the user and the users Smartphone android Device.

5. Conclusion

In the above paper, we have presented a Smartphone based fall detection using accelerometer sensors on our android devices, where wavelengths and various sensors are used to detect the fall. The best feature of this application is that it detects the fall instantly and also sends the location to the acre takers and the ambulance services using networks and immediate rescue is done. To avoid fake alarms and non risky falls there is a panic shield that could be turned off in 20 seconds to avoid fake alarm calls. It is a life saver application that could be used to save not only the. In future, we are planning to put these sensors elderly people, but also those who fall into serious life critical accidents. Only one in a thousand of things are done to save a person’s life and this application is one of them. In the future, instead of a Smartphone, we can use the human body so that even when our cellular device is not with us, we can always find help in times of need. If this feature gets to start working soon, then our lives could be safe even when our cellular devices runs out of juice or stops working.

References


